PROCEEDINGS OF THE BIOLOGICAL SOCIETY OF WASHINGTON
113(4):1064–1078. 2000.

Brachycalanus flemingeri and *B. brodskyi,* two new copepods (Crustacea: Calanoida: Phaennidae) from benthopelagic waters of the tropical Pacific

Frank D. Ferrari and E. L. Markhaseva

(FDF) Department of Invertebrate Zoology, National Museum of Natural History; Smithsonian Institution; Washington, D.C. 20560-0534, U.S.A.; (ELM) Russian Academy of Sciences, Zoological Institute; Universitetskaya nab. 1, 199034, St. Petersburg, Russia

Abstract.—*Brachycalanus flemingeri,* new species, has three setae on coxal endite of maxilla 1, a bifurcate worm-like sensory seta on the exopod of maxilla 2, a distal, semicircular protrusion posteriorly on the basis of swimming leg 1, and lacks a medial seta on coxa of swimming leg 4. *Brachycalanus brodskyi,* new species, is differentiated by its large size, 4.0 mm, and a semicircular row of small denticles distally and posteriorly on the basis of swimming leg 1. *Brachycalanus ordinarius* (Grice, 1972) is redescribed and separated from the remaining species by the exopod of maxilla 2 with a distally constricted worm-like seta with a small lobe near the point of constriction. All three species have nine sensory setae on the distal basal lobe plus exopod of maxilla 2; this number of sensory setae has been reported for one other phaennid copepod and several scolecitrichids. Suggested shared derived character states for the species of *Brachycalanus* Farran, 1905 are epicuticular extensions of the female genital complex and the following two abdominal somites, and knife-like aesthetascs on female antenna 1.

The genus *Brachycalanus* Farran, 1905 includes four species: *B. atlanticus* (Wolfenden, 1904), *B. bjornbergae* Campaner, 1978; *B. ordinarius* (Grice, 1972) and *B. rothlisbergi* Othman & Greenwood, 1988 although Othman & Greenwood (1988) suggested that specimens of *B. atlanticus* reported by Farran (1905) do not belong to the same species as the specimens of Wolfenden (1904). Different species have been reported from the North Atlantic Ocean (Wolfenden 1904, Farran 1905, Grice 1972), the South Atlantic Ocean (Campaner 1978) and the Gulf of Carpentaria in the western tropical Pacific Ocean (Othman & Greenwood 1988); only *B. atlanticus* has been reported more than once, by Wolfenden (1904) and Farran (1905). Specimens of *Brachycalanus* usually are collected from near-bottom localities at depths from 72–100 m (Campaner 1978) to 992–1000 m (Grice 1972). No adult males of a species of *Brachycalanus* have been collected. The two new *Brachycalanus* species described here are the first records of the genus from the eastern tropical Pacific Ocean. *Brachycalanus ordinarius* is redescribed, based a paratype.

Materials and Methods

The specimens from Hawaii collected on 6 July 1997 may have been in a plankton net for up to 12 hours prior to sample fixation with 4% formaldehyde; few internal tissues remain in these specimens. The specimen collected from Volcano 7 during November 1988 was fixed at its depth of capture with gluteraldehyde; most internal tissues remain. Ferrari & Markhaseva (1996, 2000), give further details about collections from Volcano 7 and Hawaii. In the

laboratory, specimens from both localities were preserved in 0.5% propylene phenoxytol/4.5% propylene glycol/95.0% deionized freshwater. During examination, specimens were cleared in steps through 50% lactic acid/50% deionized freshwater to 100% lactic acid, stained by adding a solution of chlorazol black E dissolved in 70% ethanol/30% deionized freshwater, and examined with bright-field and with differential interference optics. Drawings were made with a camera lucida. Dissected and undissected specimens are preserved in 70% ethanol/30% deionized freshwater.

Cephalic appendages are abbreviated A1 = antenna 1; A2 = antenna 2; Mn = mandible; Mx1 = maxilla 1; Mx2 = maxilla 2. Thoracic somites are Th1–7. Appendages on thoracic somites are Mxp = maxilliped (thoracopod 1); P1–5 = swimming legs 1–5 (thoracopods 2–6). The caudal ramus is CR. Measurements are lengths; the length of the whole animal is measured from the anterior edge of the cephalothorax to the posterior edge of the caudal ramus, and does not include the overlap onto the genital complex of the posterior edge of the sixth thoracic somite. Designations of appendage segments follow Ferrari (1995), Ferrari & Dahms (1998) and Ferrari & Markhaseva (2000). The coxa of the maxilliped of copepods has one lobe with a group of setae (Ferrari & Ambler 1992, Martínez Arbizu 1997); the remaining three groups of setae on the calanoid syncoxa belong to the praecoxa. Articulating armament elements of appendages are termed setae regardless of their morphology or degree of rigidity. Two setae and one aesthetasc on a segment of antenna 1 are designated 2+1; "?" indicates that a setal element was broken so that its identity on antenna 1 could not be determined and only the scar at the location of attachment of the seta was counted. Setules are epicuticular extensions of a seta; denticles are epicuticular extensions of an appendage segment; spinules are epicuticular extensions of a somite. An array of denticles whose tips point toward the distal end of an appendage are distally polarized; an array arranged in a semicircle are radially polarized. Specimens remain deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM).

Brachycalanus flemingeri new species
Figs. 1–3

Specimens.—Holotype (USNM 307711) a dissected 2.41 mm female; prosome 2.02 mm, urosome 0.44. Paratypes: (USNM 307712) 4 mature females (2.01; 2.04, two specimens; 2.37 mm) and 3 males CV (2.01; 2.07; 2.07 mm) and 1 CIV female (1.65 mm). Type locality: eastern tropical Pacific Ocean, 19°43′27.01″N, 156°04′35.46″W, off Kona, Island of Hawaii, 6 Jul 1997.

CVI Female.—(Fig. 1A) Cephalon and Th1 fused; Th2–Th4 separate; Th5 and Th6 separated but not well articulated. Laterally, posterior corners of prosome triangular; dorsally, acutely triangular and almost reaching mid-length of genital complex (Fig. 1G). Th4 with 2 sensilla laterally; ventral longer; Th5 with 1 short dorsal sensilla laterally. Genital complex and following 2 abdominal somites (Fig. 1D, E, H) with small, scale-like spinules. Genital complex symmetrical.

Rostrum (Fig. 1B, C): subdivided plate with 2 filaments.

A1: reaching Th3 and of 24 articulating segments with groups of setae: 3?, 7?, 3?, 2?, 3?, 2?, 3?, 5?, 1, 1, 3?, 1, 3?, 1, 2?, 1, 2?, 2?, 1, 1, 2?, 2?, 2?, 5+1.

A2 (Fig. 2A): coxa with 1 seta and denticles. Basis with 2 setae. Ri 2-segmented with 2 and 14 (6 terminal and 8 subterminal) setae. Re 7 articulated segments with 0, 1, 1, 1, 1, 1, and 1+3 setae; 2nd segment with several small indentations on medial face and seta minute.

Mn: coxal gnathobase (Fig. 2C) somewhat elongate with 3 compound and 4 simple teeth and 1 seta. Basis with 3 setae (Fig. 2B). Re indistinctly segmented apparently

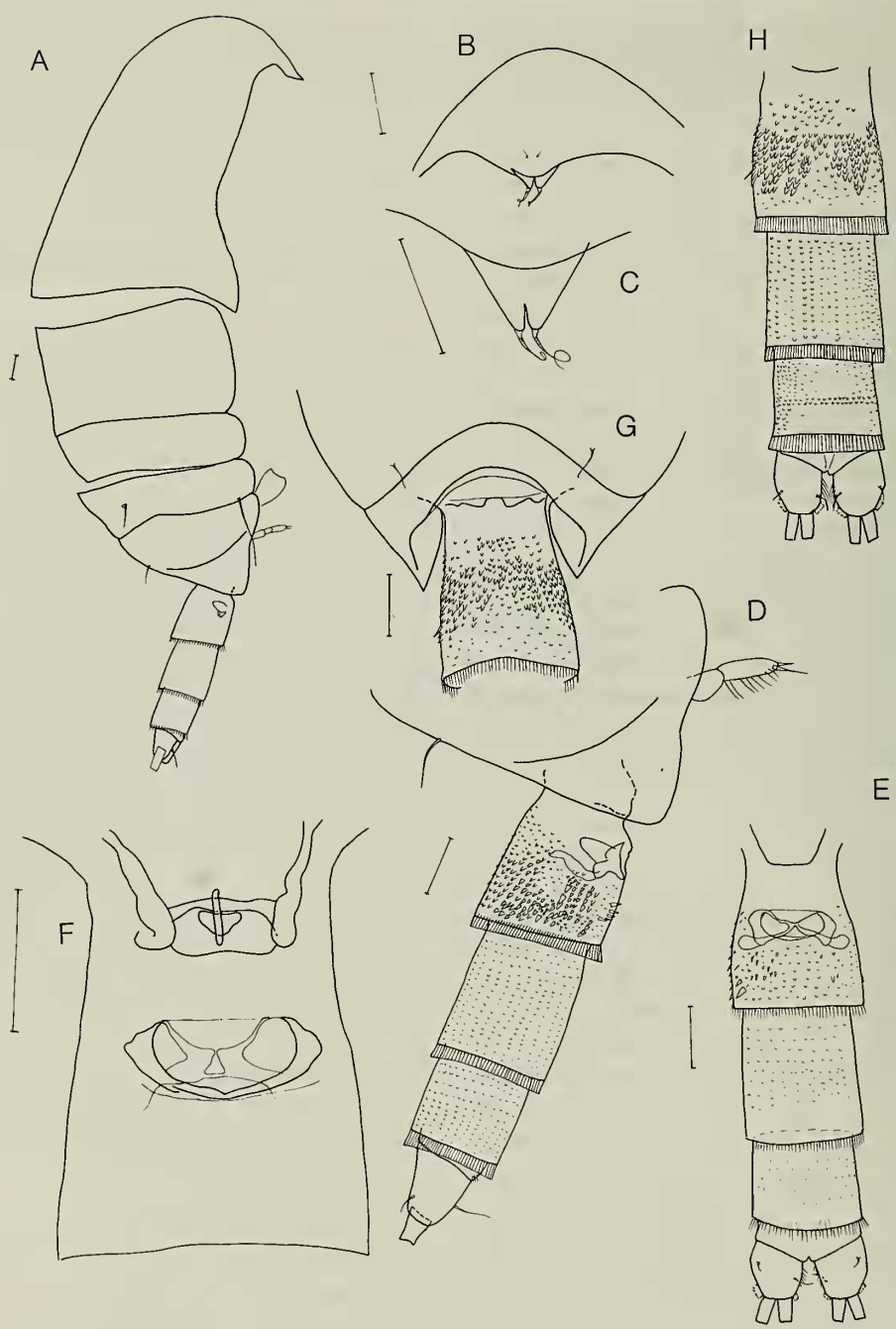

Fig. 1. *Brachycalanus flemingeri* new species. A, habitus, right lateral; B, anterior part of cephalon, ventral; C, rostrum, anterior-ventral; D, Th5–6 and urosome, right lateral; E, urosome, ventral; F, genital complex, ventral; G, posterior Th4, Th5–6 and genital complex, dorsal; H, urosome dorsal. Scale lines are 0.1 mm.

with 1, 1, 1, 1, 2 terminal setae; Ri 2-segmented with 2 and 9 setae.

Mx1: praecoxa elongate with 9 terminal, 1 anterior and 4 posterior setae (Fig. 2E); coxal epipodite with 1 thin, short seta and 8 long, thick setae; coxal endite with 3 setae; 1st and 2nd basal endites with 4 and 5 setae respectively (Fig. 2D). Ri with 11 setae (3+3+5); Re with 10 setae.

Mx2 (Fig. 2G): proximal praecoxal endite with 5 setae; distal with 3 setae, 1 poorly sclerotized. Proximal coxal endite with 1 short, poorly sclerotized sensory seta and 2 long well-sclerotized setae; distal coxal endite with 1 thick and 2 thin setae. Proximal basal endite with 1 long, thick seta, 1 long, thin seta and 2 poorly sclerotized sensory setae. Distal basal lobe + Re with 9 sensory setae; 7 brush-like setae with short setules and 2 worm-like setae, 1 of which is bifurcate toward its distal end.

Mxp (Fig. 2F): syncoxa with 1 worm-like seta on proximal lobe; 1 sclerotized and 1 worm-like sensory seta on middle lobe; 1 sclerotized and 1 brush-like sensory seta with short setules on distal lobe; coxal lobe with 3 setae and distal denticles. Basis with 3 setae on unattentuated proximal lobe and 2 setae on distal lobe; denticles proximally. Ri segments from proximal to distal with 4, 4, 3, 4 (1 lateral), 4 (1 lateral) setae respectively.

P1 (Fig. 3A, B): all segments with denticles, anteriorly and posteriorly. Coxa without seta. Basis with medial seta and distal semicircular protrusion on posterior face. Re 3-segmented, proximal with 1 lateral seta, middle with 1 medial and 1 lateral seta, distal with 3 medial, 1 terminal, 1 lateral setae; lateral seta on proximal segment reaches to base of lateral seta on middle segment and lateral seta on middle segment reaches to base of lateral seta on distal segment. Ri a 1-segmented complex with 3 medial and 2 terminal setae. Anterior face of Von Vaupel Klein's organ with well-developed triangular protuberence, anterior row of long denticles proximally and posterior pore.

P2 (Fig. 3C, D): all segments anteriorly and posteriorly with complex arrays of large and small denticles; arrays may be distally or radially polarized. Coxa with medial seta. Basis without seta. Re 3-segmented, proximal with 1 medial and 1 lateral seta, middle with 1 medial and 1 lateral seta, distal with 4 medial, 1 terminal, 3 lateral setae. Ri 2-segmented, proximal with 1 medial seta, distal with 2 medial, 2 terminal, 1 lateral setae.

P3 (Fig. 3E, F): all segments anteriorly and posteriorly with complex arrays of large and small denticles; arrays may be distally or radially polarized. Coxa with medial seta. Basis without seta. Re 3-segmented, proximal with 1 medial and 1 lateral seta, middle with 1 medial and 1 lateral seta, distal with 4 medial, 1 terminal, 3 lateral setae. Ri 3-segmented, proximal with 1 medial seta, middle with 1 medial seta, distal with 2 medial, 2 terminal, 1 lateral setae.

P4 (Fig. 3G–I): all segments except proximal endopodal anteriorly and posteriorly with complex arrays of large and small denticles; arrays may be distally or radially polarized. Coxa without seta. Basis without seta. Re 3-segmented, proximal with 1 medial and 1 lateral seta, middle with 1 medial and 1 lateral seta, distal with 4 medial, 1 terminal, 3 lateral setae. Ri 3-segmented, proximal with 1 medial seta, middle with 1 medial seta, distal with 2 medial, 2 terminal, 1 lateral setae.

P5 (Fig. 3J): all 3 segments posteriorly with denticles of various lengths. Coxa and basis without a seta. Re 1-segmented with 1 medial, 2 terminal and 1 lateral setae.

CR (Fig. 2E): 4 large, terminal setae, 1 small medial-dorsal seta, and 1 small lateral-ventral seta.

Etymology.—The species name honors Abraham Fleminger of Scripps Institution of Oceanography for his contributions to the systematics of calanoid copepods.

Remarks.—Autapomorphies for *B. flemingeri* include: one bifurcate, worm-like sensory seta on exopod of maxilla 2; basis of swimming leg 1 with semicircular pro-

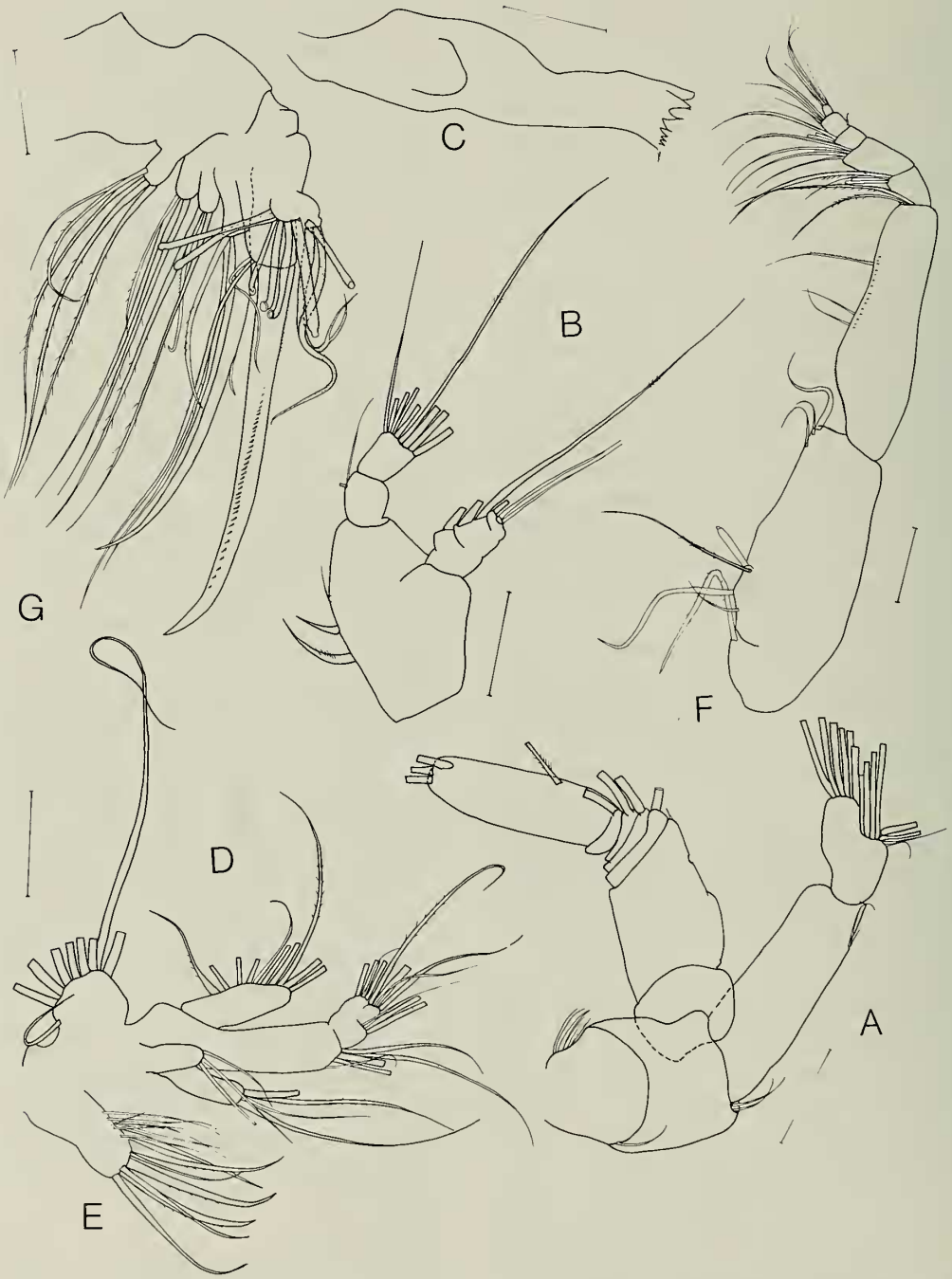

Fig. 2. *Brachycalanus flemingeri,* new species. A, antenna 2, ventral; B, mandibular palp, dorsal; C, mandibular gnathobase, distal; D, maxilla 1, anterior; E, maxilla 1, praecoxal lobe, posterior, distal down; F, maxilliped, anterior; G, maxilla 2 anterior. Scale lines are 0.1 mm.

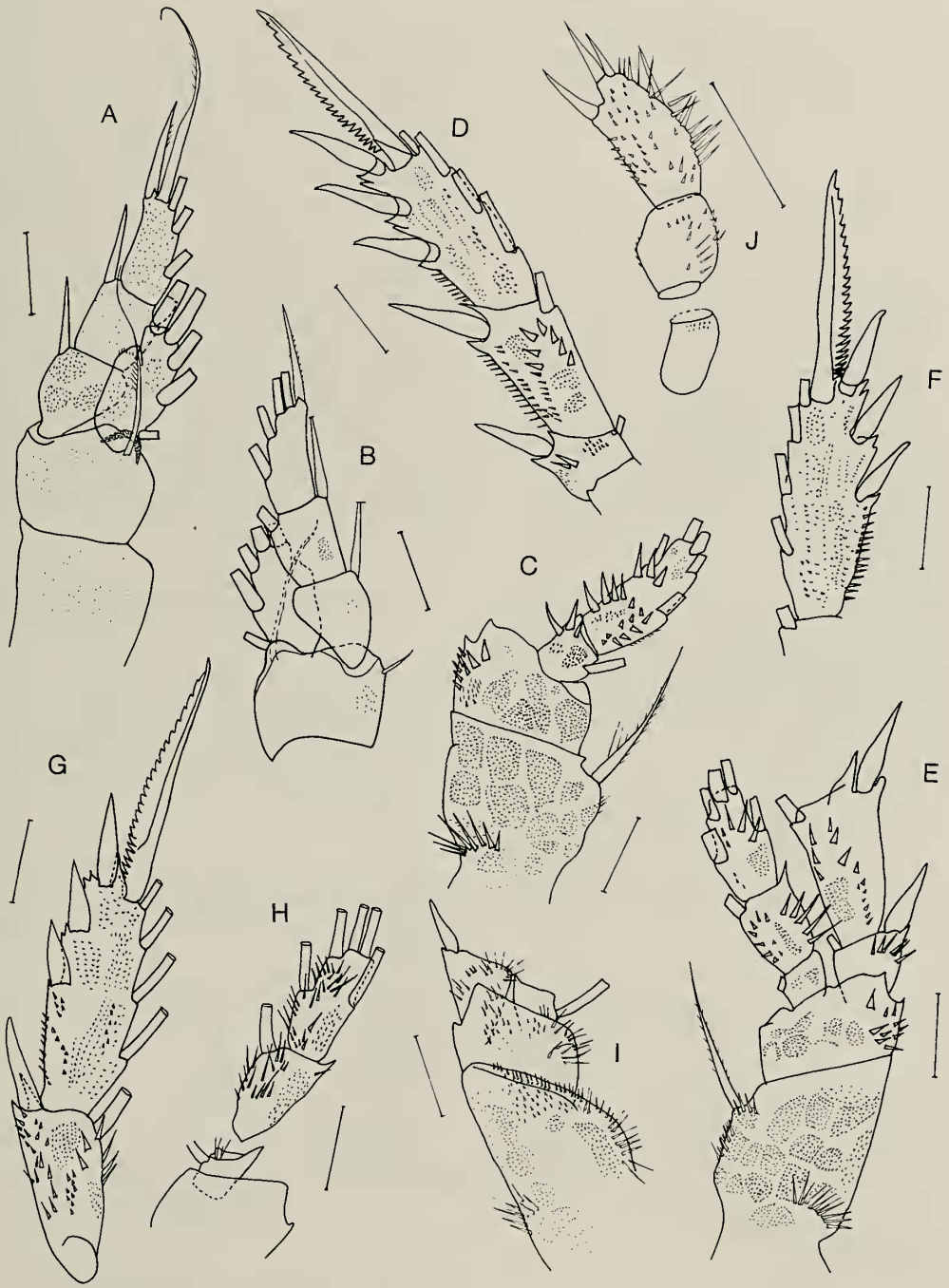

Fig. 3. *Brachycalanus flemingeri,* new species. A, P1, anterior; B, basis and rami of P1, posterior; C, coxa, basis and endopod of P2, posterior; D, exopod of P2, posterior, medial seta of proximal segment missing; E, coxa, basis, endopod and proximal and middle segment of exopod of P3, posterior; F, distal part of middle segment and distal segment of exopod of P3, posterior; G, middle segment and distal segment of exopod of left P4, posterior; H, basis and proximal segment detached from middle and distal segments of endopod of right P4, posterior; I, coxa, basis and proximal ramal segments of left P4, posterior, medial seta of proximal exopodal segment missing; J, P5, posterior, coxa detached. Scale lines are 0.1 mm.

trusion at the base of medial seta; three setae on coxal endite of maxilla 1 (rather than two setae); and swimming leg 4 without a medial coxal seta.

Brachycalanus brodskyi, new species
Figs. 4–7

Specimens.—Holotype (USNM 307714) a dissected 4.0 mm female; prosome 3.3 mm, urosome 1.0 mm. Type locality: eastern tropical Pacific Ocean 1–5 m above bottom at base of Volcano 7 (13°23′N, 102°27′W), at depths of 2945–3010 m, dive 2147, Nov 1988. The anterior seta on praecoxal endite of Mx1 of the single known specimen apparently broken; one seta on the middle praecoxal lobe of Mxp apparently broken.

CVI female.—Differs from *B. flemingeri* as follows: in habitus, dorsally posterior corners of prosome exceeding the middle length of genital somite (Fig. 4H). Genital complex with long denticles posterior-ventrally.

A1 (Fig. 5A–C): 3, 6+1, 2+1, 1+1, 2+1, 2?, 2+1, 4+1, 1, 1, 2+1, 1, 2+1, 1, 2, 1, 2, 1+1, 1, 1, 2?, 2, 2, 5+1. Many setae and aesthetascs present on this specimen.

A2 (Fig. 6A), Mn (Fig. 6B, C), Mx1 (Fig. 6D) as illustrated.

Mx2: proximal and distal coxal endite each with 1 poorly sclerotized sensory seta (Fig. 6E). Distal basal lobe + Re with 9 sensory setae, 8 brush-like with longer setules (Fig. 6F) and 1 worm-like seta.

Mxp: (Fig. 6G, H) as illustrated.

P1 (Fig. 7A, B): basis with a semicircular row of small denticles posterior and distal near origin of endopod, and without semicircular protrusion.

P2 (Fig. 7C, D), P3 (Fig. 7E, F) as illustrated.

P4 (Fig. 7G, H): coxa with medial set; middle and distal segments of both rami lost.

P5 (Fig. 7I) as illustrated.

Etymology.—The species name honors Konstantin Abramovich Brodsky of the Zoological Institute of the Russian Academy of Sciences, for his contributions to the systematics of calanoid copepods.

Remarks.—*Brachycalanus brodskyi* new species differs from the other species of the genus by its size 4.0 mm (remaining species: 1.52–3.40 mm); basis of swimming leg 1 with semicircular row of small denticles near origin of the medial seta.

Brachycalanus brodskyi shares eight brush-like setae with long filaments and 1 worm-like seta on distal basal lobe + exopod of maxilla 2 with *B. bjornbergae*; this composition apparently is shared also with *B. rothlisbergi* (Othman & Greenwood 1988 fig. 2C). *B. brodskyi* shares with *B. flemingeri* the acute triangular shape of posterior corners of prosome.

Brachycalanus ordinarius (Grice, 1972)
Fig. 8

Xanthocalanus ordinarius.—Grice, 1972: 237, figs. 101–119.

Brachycalanus ordinarius.—Campaner, 1978: 976–977. Othman & Greenwood, 1988: 357.

CVI female, paratype.—USNM 137176; differs from *B. flemingeri* as follows: in habitus, posterior corners of Th6 rounded (Fig. 8A).

A1 (Fig. 8B–D): 24 articulated segments with setal groups containing: 3, 6+1, 2+1, 2?, 2+1, 2, 2+1, 4+1, 1, 1, 2+1, 1, 2+1, 1, 2, 1, 1+1, 1+1, 1, 1, 2, 2, 2, 5+1 setae.

A2: without small distal seta on Re2.

Mx2: distal praecoxal endite without a poorly sclerotized seta; distal basipod lobe + Re with 7 brush-like and 2 worm-like sensory setae (Fig. 8F); 1 worm-like seta constricted distally with a small lobe near point of constriction (Fig. 8G), the other a simple worm-like seta.

Mxp: worm-like sensory seta of proximal lobe with long setules (Fig. 8H).

P1: basis without semicircular row of small denticles or semicircular protrusion near origin of medial seta; lateral seta on

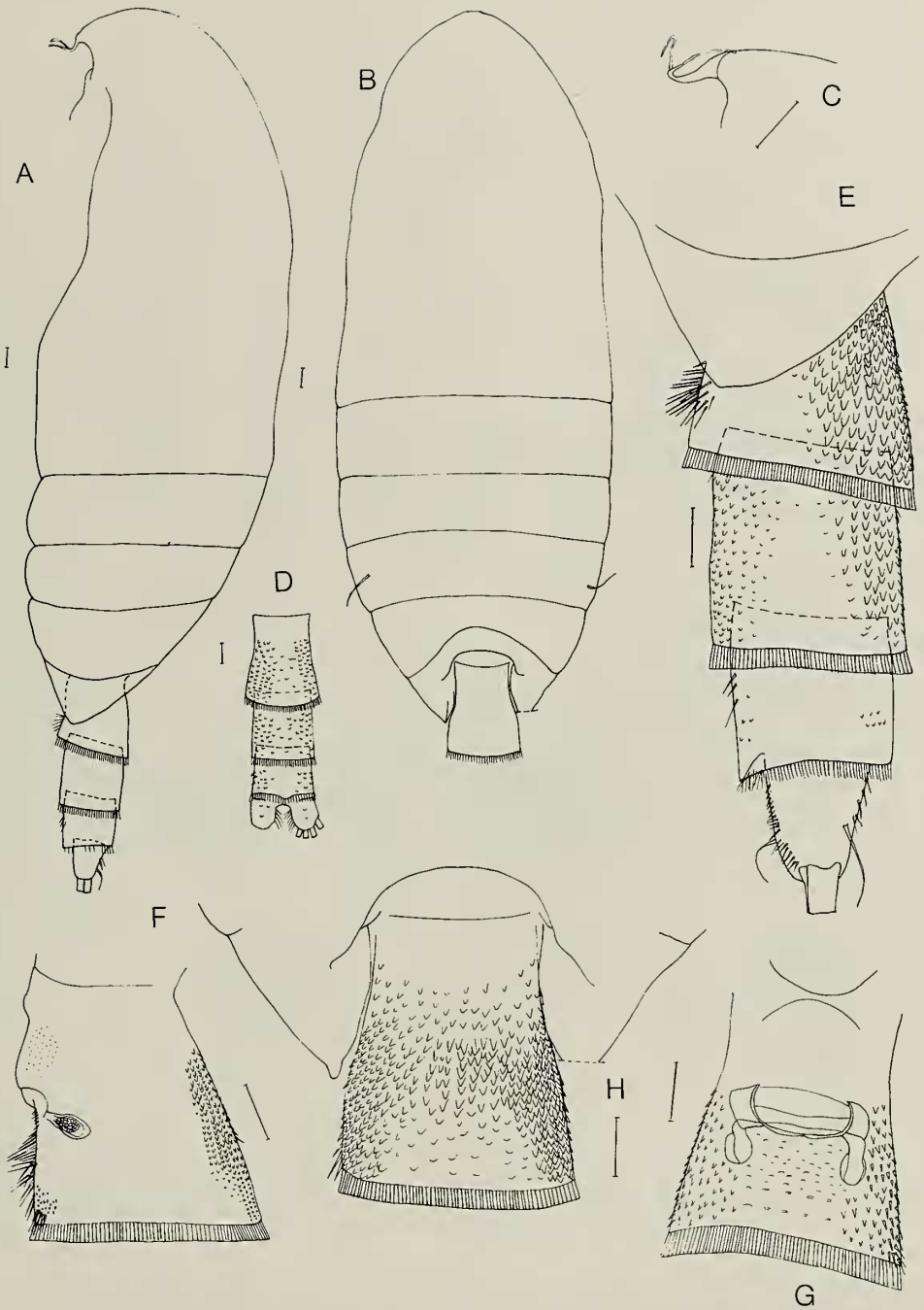

Fig. 4. *Brachycalanus brodskyi,* new species. A, habitus, left lateral; B, prosome and genital complex, dorsal; C, rostrum, lateral; D, urosome, dorsal; E, posterior Th5–6 and urosome, left lateral; F, genital complex, left lateral; G, genital complex, ventral; H, genital complex, dorsal. Scale lines are 0.1 mm.

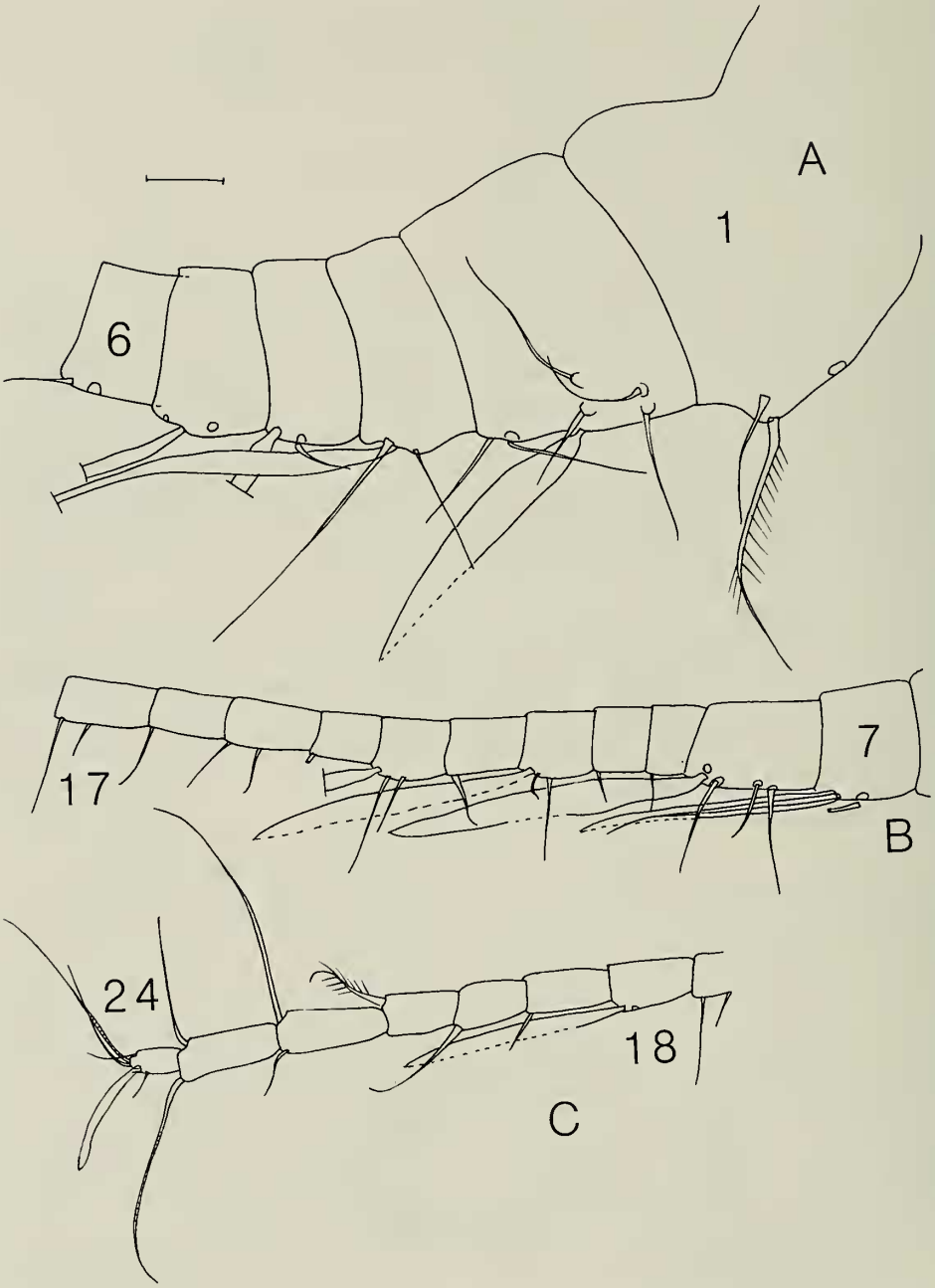

Fig. 5. *Brachycalanus brodskyi,* new species. A, antenna 1, articulating segments 1–6, ventral down; B, antenna 1, articulating segments 7–17, ventral down; C, antenna 1, articulating segments 18–24, ventral down. Broken line indicates poorly resolved edge of aesthetasc. All scale lines are 0.1 mm.

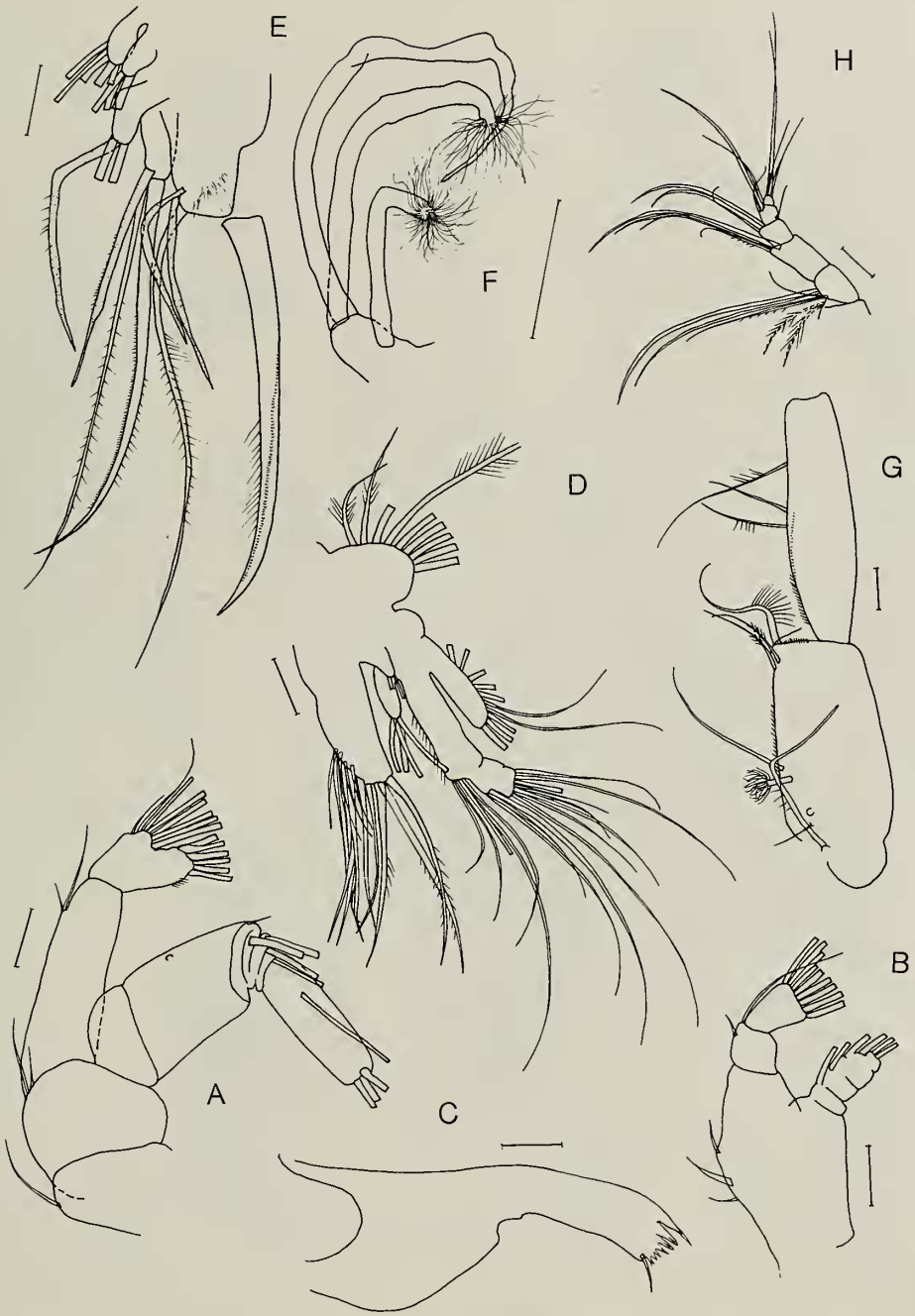

Fig. 6. *Brachycalanus brodskyi,* new species. A, antenna 2, dorsal; B, mandibular palp, ventral; C, mandibular gnathobase, distal; D, maxilla 1, anterior; E, maxilla 2, posterior, distal basal lobe + exopod omitted; F, exopod of maxilla 2 showing 3 terminal aesthetascs; G, syncoxa and basis of maxilliped, anterior; H, endopod of maxilliped, anterior. All scale lines are 0.1 mm.

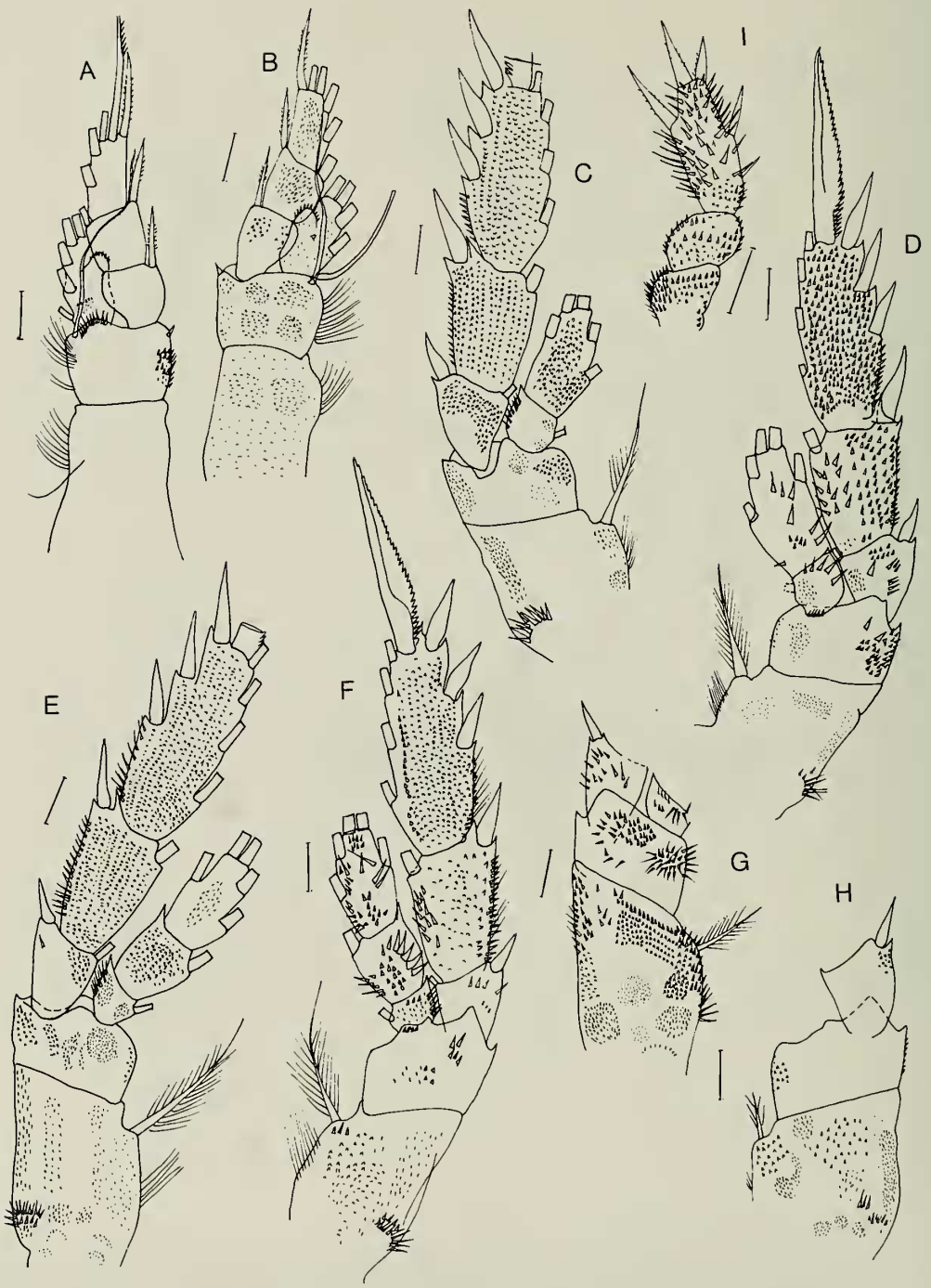

Fig. 7. *Brachycalanus brodskyi,* new species. A, P1, posterior; B, P1, anterior; C, P2, anterior, terminal seta cutoff; D, P2, posterior; E, P3, anterior, terminal seta cut off; F, P3, posterior; G, coxa, basis and proximal ramal segments of P4, posterior; H, coxa, basis and proximal exopodal segment of P4, anterior; I, P5, posterior. All scale lines are 0.1 mm.

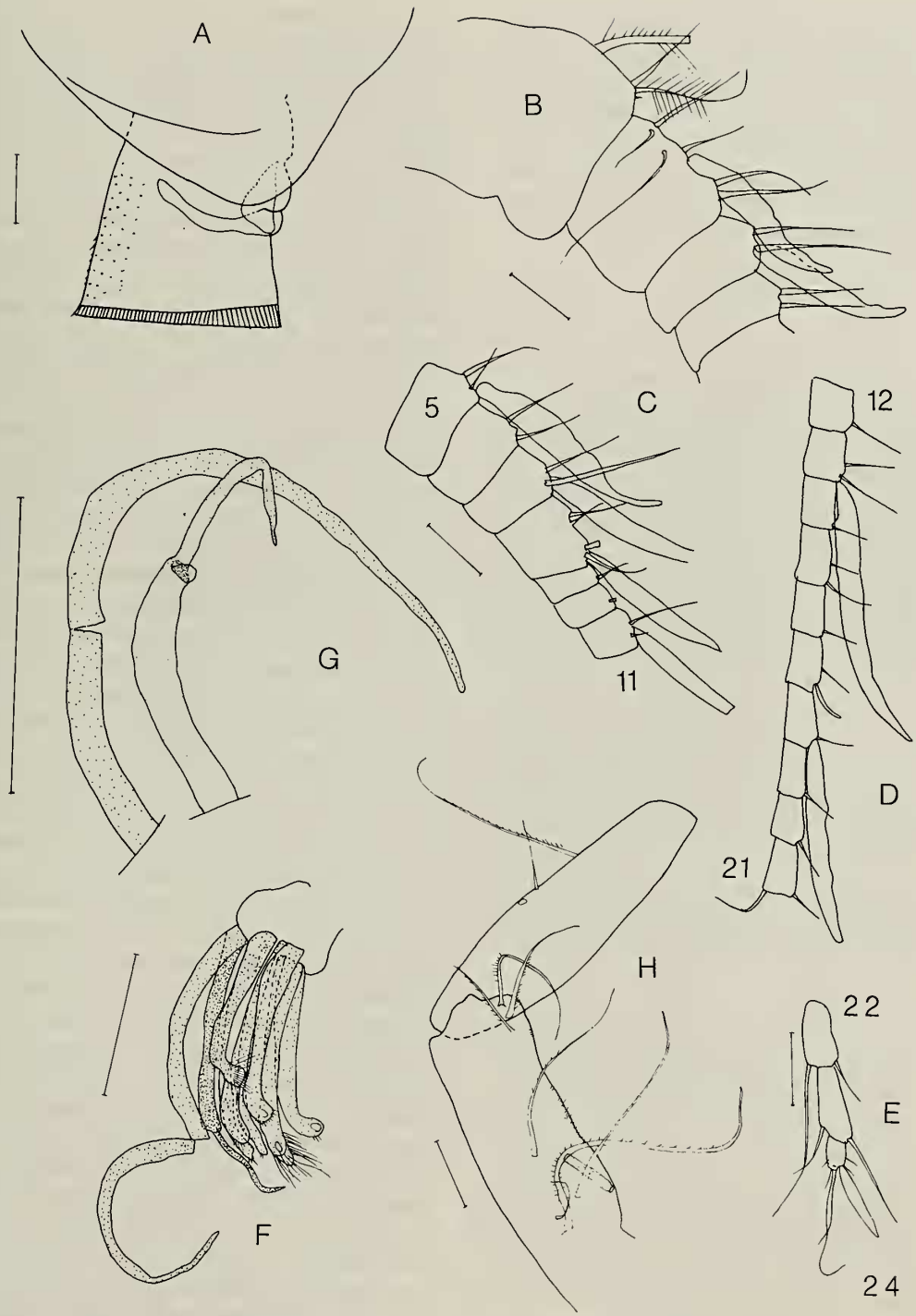

Fig. 8. *Brachycalanus ordinarius* (Grice, 1972). A, posterior Th5–6 and genital complex, right lateral; B, antenna 1, articulating segments 1–4, ventral toward right; C, antenna 1, articulating segments 5–11, ventral toward right; D, antenna 1, articulating segments 12–21, ventral right; E, antenna 1, articulating segments 22–24, ventral right; F, distal basal lobe and exopod of maxilla 2; G, worm-like setae of exopod of maxilla 2; H, syncoxa and basis, with distal lobe omitted, of maxilliped, anterior. All scale lines are 0.1 mm.

middle segment not reaching base of lateral seta of distal segment.

Remarks.—Brachycalanus ordinarius differs from the remaining species of the genus in possessing 1 worm-like seta constricted distally with a small lobe near point of constriction on the distal basal lobe + exopod of maxilla 2.

Discussion

The genus *Brachycalanus* was established by Farran (1905: 41) for three specimens of *B. atlanticus* which were "... washed from sand brought up by a townet on the trawl ... (off the west coast of Ireland) .... They measured 2.5, 2.0 and 1.52 mm respectively." Farran described the largest specimen, except for P5, "which were only found in the smallest specimen, which while appearing fully developed in other respects, still showed immature segmentation of the abdomen". Farran mentioned in the description of the species "While the above was in press a description of this species under the name of *Xanthocalanus atlanticus,* was published by Dr. Wolfenden" (Farran 1905: 42). In establishing the genus, Farran mentioned that it is closely allied to *Xanthocalanus* Giesbrecht, 1892 and noted as distinguishing characters the shape of rostrum and an extremely short A1.

Brachycalanus was diagnosed by Campaner (1978: 976) based on the then three known species; he removed *B. minutus* Grice, 1972 and gave the total number and kind of sensory setae on the ramus of maxilla 2 as 1 worm-like and "(?5) 7–8" brush-like setae. In a later diagnosis, Bradford et al. (1983) added that the urosome, and dorsal and ventral (actually anterior and posterior) surfaces of P1–P5 were covered with spines, an important character distinguishing the genus from *Xanthocalanus.* A later discussion of *Brachycalanus* by Othman & Greenwood (1988) noted the presence of knife-shaped aesthetascs on the antenna 1 as derived character state for the genus. Othman & Greenwood (1988: 355) also suggested that Farran's (1905) specimens of *B. atlanticus* were not conspecific with those of Wolfenden (1904). Ohtsuka et al. (1998) pointed out that *Brachycalanus* shares with at least some species of *Xanthocalanus* a proximal basal endite of maxilla 2 with two worm-like sensory setae, and a syncoxa of the maxilliped with one or two worm-like sensory setae in addition to one brush-like sensory seta. These have not been reported for other phaennid genera.

We found very few differences to separate the three species of *Brachycalanus* studied here from the remaining species. However, the number of autapomorphies and degree of divergence among the species should become more apparent after careful redescription, particularly of the setation of maxilla 1 and maxilla 2, and discovery of males of the five species. Among the three species here that we place in *Brachycalanus,* there are different combinations of worm-like and brush-like setae among the nine sensory setae of the distal lobe and exopod of maxilla 2: one worm-like and eight brush-like setae in *B. bjornbergae* and *B. brodskyi*; two worm-like and seven brush-like in *B. ordinarius* and *B. flemingeri.* However, one worm-like seta each of *B. ordinarius* and *B. flemingeri* appears to be more specialized; one worm-like seta of *B. ordinarius* is similar to a fleshy seta (Campaner 1978: 968) with a small lobe, and one worm-like setae of *B. flemingeri* is bifurcate. It appears that a simple combination of the different kinds of sensory setae cannot be used to diagnose the genus *Brachycalanus.* Whether the number of sensory setae which are not worm-like are phylogenetically significant, remains to be determined. At this time we suggest that synapomorphies for the species of *Brachycalanus* are the presence of spinules on the female genital complex and following two abdominal somites, and knife-like aesthetascs on female antenna 1.

Species of the genus *Brachycalanus* pres-

ently are placed in the Phaennidae, one of five families within the superfamily Clausocalanoidea that possess sensory setae or aesthetascs on the distal basal lobe plus exopod of maxilla 2, and on the maxilliped (Nishida & Ohtsuka 1997). Bradford (1973) and Bradford et al. (1983) suggested that the number and the kinds of these sensory setae be used in diagnosing the Phaennidae and the Scolecitrichidae. Detailed descriptions of this part of maxilla 2 were not provided for the type species of *Brachycalanus* (Wolfenden, 1904) or in the original description of the genus (Farran 1905). In his diagnosis, Campaner (1978: 976) mentioned one worm-like plus "(5?) 7–8" brush-like sensory setae; Othman & Greenwood (1988) described this limb of *B. rothlisbergi* with one worm-like and ten brush-like setae (although only eight brush-like setae can be counted in their fig. 2C); finally, illustrations by Grice (1972: 235, fig. 109b) for *B. ordinarius* show two worm-like plus six brush-like sensory setae. We have observed nine such setae for *B. flemingeri, B. brodskyi,* and a paratype of *B. ordinarius.*

The presence of nine setae on the distal basal lobe plus exopod of maxilla 2 of these three *Brachycalanus,* another phaennid, *Xanthocalanus pavlovskii* Brodsky, 1955 as well as all five species of the scolecitrichid *Landrumius* (see Park 1983) and the scolecitrichid *Xantharus renatehaassae* Schulz, 1998 indicates that the number of such setae has not been conserved in these families as they are understood today. Although most descriptions of Clausocalanoida species with simple, sclerotized setae on the distal basal lobe plus exopod mention eight of these setae, a recent redescription of *Pseudochirella obesa* Sars, 1920 by Vaupel Klein & Rijerkerk (1997) states and figures nine such setae. Ohtsuka et al. (1998) suggested that brush-like setae may be derived from worm-like setae because the dendritic cilia of a worm-like setae are enclosed within a thin cuticle, homologous to the thick cuticle of sclerotized setae, while the cuticle of a brush-like seta is open distally so that its dendritic cilia are in direct contact with the aquatic environment, as described by Nishida & Ohtsuka (1997). The number present on the ancestral clausocalanoidan and the ancestor of the lineage which includes the Aetideidae, Phaennidae and Scolecitrichidae, and the number and kinds of transformations of these ancestral states must await a careful redescriptions of the species of these families.

Acknowledgments

We thank Dr. Karen F. Wishner, University of Rhode Island, for the specimens from Volcano 7 and Dr. Edward J. Buskey, University of Texas, for those from Hawaii. E. L. M. thanks the Smithsonian Institution and the American Philosophical Society for travel support to the National Museum of Natural History; Smithsonian Institution; Washington, D.C.

Literature Cited

Bradford, J. 1973. Revision of family and some generic definitions in the Phaennidae and Scolecithricidae (Copepoda: Calanoida).—New Zealand Journal of Marine and Freshwater Research 7:133–152.

———, L. Haakonssen, & J. Jillett. 1983. The marine fauna of New Zealand: pelagic calanoid copepods: families Euchaetidae, Phaennidae, Scolecithricidae, Diaixidae, and Tharybidae.—New Zealand Oceanographic Institute Memoir 90, 150 pp.

Brodsky, K. A. 1955. On the copepod (Calanoida) fauna of the Kuril-Kamchatka trench.—Trudy Instituta Okeanologii Akademii Nauk SSSR 12: 184–209. [in Russian]

Campaner, A. F. 1978. On some new planktobenthic Aetideidae and Phaennidae (Copepoda, Calanoida) from the Brazilian continental shelf. II. Phaennidae.—Ciencia e Cultura 30:966–982.

Farran, G. P. 1905. Report on the Copepoda of the Atlantic slope off Counties Mayo and Galway.—Annual Report of the Fisheries Ireland, 1902–1903, part 2, (2):23–52.

Ferrari, F. D. 1995. Six copepodid stages of *Ridgewayia klausruetzleri,* a new species of copepod crustacean (Ridgewayiidae, Calanoida) from the barrier reef in Belize, with comments on appendage development.—Proceedings of the Biological Society of Washington 108:180–200.

———, & J. W. Ambler. 1992. Nauplii and copepodids of the cyclopoid copepod *Dioithona oculata* (Oithonidae) from a mangrove cay in Belize.—Proceedings of the Biological Society of Washington 105:275–298.

———, & H.-U. Dahms. 1998. Segmental homologies of the maxilliped of some copepods as inferred by comparing setal numbers during copepodid development.—Journal of Crustacean Biology 18:298–307.

———, & E. L. Markhaseva. 1996. *Parkius karenwishnerae,* a new genus and species of calanoid copepod (Parkiidae, new family) from benthopelagic waters of the eastern tropical Pacific Ocean.—Proceedings of the Biological Society of Washington 109:264–285.

———, & ———. 2000. *Griceus buskeyi,* a new genus and species of calanoid copepod (Crustacea) from benthopelagic waters off Hawaii.—Proceedings of the Biological Society of Washington 113:78–88.

Giesbrecht, W. 1892. Systematik und Faunistik der pelagischen Copepoden des Golfes von Neapel und der angrenzenden Meeres-abschnitte.—Fauna und Flora des Golfes von Neapel und der angrenzenden Meeres-abschnitte 19:1–831 + 54 pls.

Grice, G. D. 1972. The existence of a bottom-living calanoid copepod fauna in deep-water with descriptions of five new species.—Crustaceana 23:219–243.

Martínez Arbizu, P. 1997. A new genus of cyclopinid copepods (Crustacea), with a redescription of *Smirnovipina barentsiana* comb. nov. (Smirnov, 1931).—Sarsia 82:313–323.

Nishida, S., & S. Ohtsuka. 1997. Ultrastructure of the mouthpart sensory setae in mesopelagic copepods of the family Scolecitrichidae.—Plankton Biology and Ecology 44:81–90.

Ohtsuka, S., I. Takeuchi, & A. Tanimura. 1998. *Xanthocalanus gracilis* and *Tharybis magna* (Copepoda, Calanoida) rediscovered from the Antarctic Ocean with baited traps.—Journal of Natural History 32:785–804.

Othman, B. H. R., & J. G. Greenwood. 1988. *Brachycalanus rothlisbergi,* a new species of planktobenthic copepod (Calanoida, Phaennidae) from the Gulf of Carpentaria, Australia.—Records of the Australian Museum 40:353–358.

Park, T. 1983. Calanoid copepods of some scolecithricid genera from antarctic and subantarctic waters.—Antarctic Research Series 38:165–213.

Sars, G. O. 1920. Calanoidés recueillis pedant les campagnes de S. A. S. le Prince Albert de Monaco (Nouveau supplément).—Bulletin Institut Océanographic (Monaco) 377:1–20.

Schulz, K. 1998. A new species of *Xantharus* Andronov, 1981 (Copepoda: Calanoida) from the mesopelagic zone of the Antarctic Ocean.—Helgolaender Meeresuntersuchungen 52:41–49.

Vaupel Klein, J. C. von, & C. D. M. Rijerkerk. 1997. A detailed redescription of the *Pseudochirella obesa* female.(Copepoda, Calanoida). II. Antennae and mouthparts.—Crustaceana 70:394–417.

Wolfenden, R. N. 1904. Notes on the Copepoda of the North Atlantic Sea and the Faroe Channel.—Journal of the Marine Biological Association of the United Kingdom 7:110–146.